BNL Covariance Effort

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Advanced Fuel Cycle Initiative (AFCI)

Major covariance effort by BNL and LANL

List of nuclei in AFCI (priority materials in **bold**)

^{1}H	^{28}**Si**	^{92}**Mo**	^{109}**Ag**	^{149}**Sm**	^{232}Th
^{2}H	^{29}**Si**	^{94}**Mo**	^{127}I	^{151}**Sm**	^{233}U
^{4}**He**	^{30}**Si**	^{95}**Mo**	^{129}I	^{152}Sm	^{234}U
^{6}Li	^{50}Cr	^{96}**Mo**	^{131}**Xe**	^{153}**Eu**	^{235}**U**
^{7}Li	^{52}**Cr**	^{97}**Mo**	^{132}Xe	^{155}Eu	^{236}**U**
^{9}Be	^{53}**Cr**	^{98}**Mo**	^{134}Xe	^{155}Gd	^{238}**U**
^{10}**B**	^{55}**Mn**	^{100}**Mo**	^{133}**Cs**	^{156}Gd	^{237}**Np**
^{11}**B**	^{54}Fe	^{99}**Tc**	^{135}**Cs**	^{157}Gd	^{238}**Pu**
^{12}**C**	^{56}**Fe**	^{101}**Ru**	^{139}La	^{158}Gd	^{239}**Pu**
^{15}**N**	^{57}**Fe**	^{102}**Ru**	^{141}Ce	^{160}Gd	^{240}**Pu**
^{16}**O**	^{58}**Ni**	^{103}**Ru**	^{141}**Pr**	^{166}Er	^{241}**Pu**
^{19}F	^{60}Ni	^{104}**Ru**	^{143}**Nd**	^{167}Er	^{242}**Pu**
^{23}**Na**	^{90}**Zr**	^{106}Ru	^{145}**Nd**	^{168}Er	^{241}**Am**
^{24}Mg	^{91}**Zr**	^{103}**Rh**	^{146}Nd	^{170}Er	^{242m}**Am**
^{25}Mg	^{92}**Zr**	^{105}**Pd**	^{148}Nd	^{204}**Pb**	^{243}**Am**
^{26}Mg	^{93}Zr	^{106}Pd	^{147}**Pm**	^{206}**Pb**	^{242}**Cm**
^{27}Al	^{94}**Zr**	^{107}**Pd**		^{207}**Pb**	^{243}**Cm**
	^{95}Zr	^{108}Pd		^{208}**Pb**	^{244}**Cm**
	^{96}Zr			^{209}**Bi**	^{245}**Cm**
	^{95}Nb				^{246}**Cm**

AFCI/GNEP project will provide 110 covariances, which will serve as a reference for constructing ENDF-6 formatted covariance files for ENDF/B-VII.1.

LANL - light nuclei, actinides, fission spectra.

BNL - structural materials, 23-Na, minor actinides, and all the rest including RR.

- AFCI-1.2 library, August 2009
- AFCI-1.3 library, April 2010
- AFCI-2.0 library, August 2010 (to be used by SG33)

Covariance methodology at BNL
Strength in diversity

- Thermal and Resonance Region (source: Atlas of Neutron Resonances)
  - MF32 with scattering radius and thermal point uncertainties reproduced through correlations (if possible)
  - MF33 through the recently developed 'kernel approximation'
  - MF32 with systematic uncertainties in MF33
  - 'low-fidelity' (Mark Williams) solution
  - Assimilation
- Fast neutron range (MF33)
  - EMPIRE/KALMAN with/without experimental data
  - Dispersion analysis - differences between evaluations
  - Reconsider previous work
  - Assimilation
- Challenges
  - (i) correlations, (ii) correlations, (iii) correlations, ...
  - Tendency of the rigorous methods to provide unbelievable uncertainties
  - Producing uncertainties for the existing files
- Goal for VII.1: provide consistent and **reasonable** set of covariances for nuclei relevant to AFCI (extensive checking)

Covariances for structural materials

^{52}Cr, ^{56}Fe, ^{58}Ni

M. Pigni

- ENDF/B-VI.8 covariances in fast neutron region, due to Hetrick et al. (1991) who authored evaluations, **restored!**
- Were dropped in VII.0 mostly because of RR
- Uncertainties increased in the above-threshold regions due to:
  - discrepancy between VII.0 and other libraries
  - more pessimistic JENDL-3.3 estimates

Changes in ^{56}Fe

E (MeV)	Uncertainty (original)	Uncertainty (adopted)	Reaction
1-2	1.5%	7.5%	Total (MT=1)
1-2	3.9%	15.9%	Absorption (MT=3)
1-2	3.3%	15.9%	1st Exc. State (MT=51)
10-20	8.9%	61.5%	Capture (MT=102)

Covariances for structural materials

^{52}Cr, ^{56}Fe, ^{58}Ni

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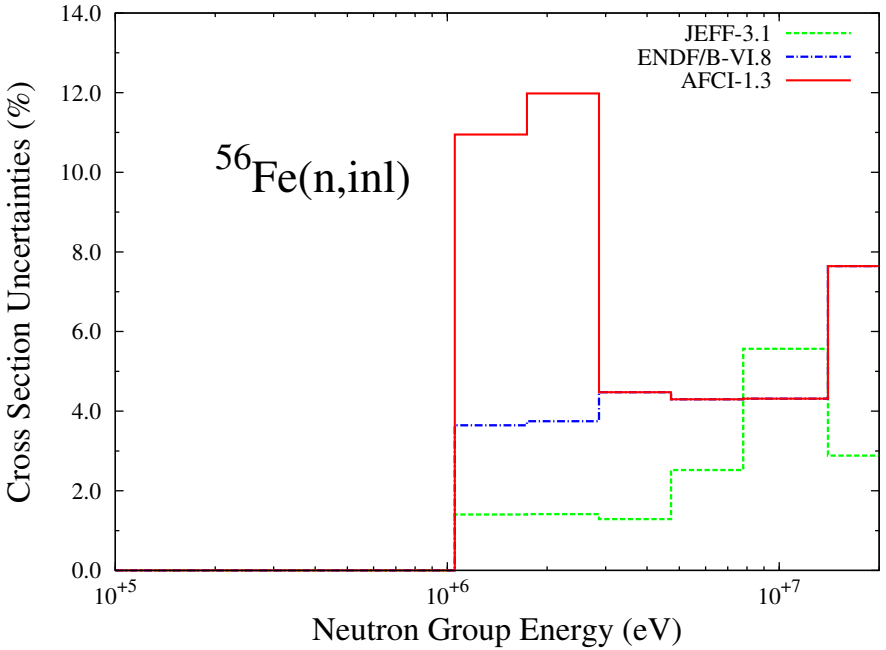
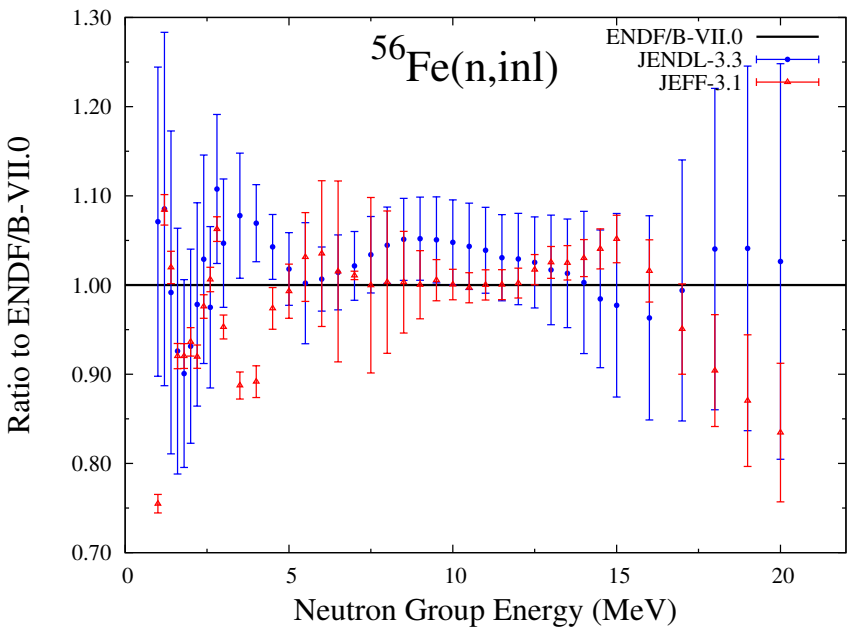


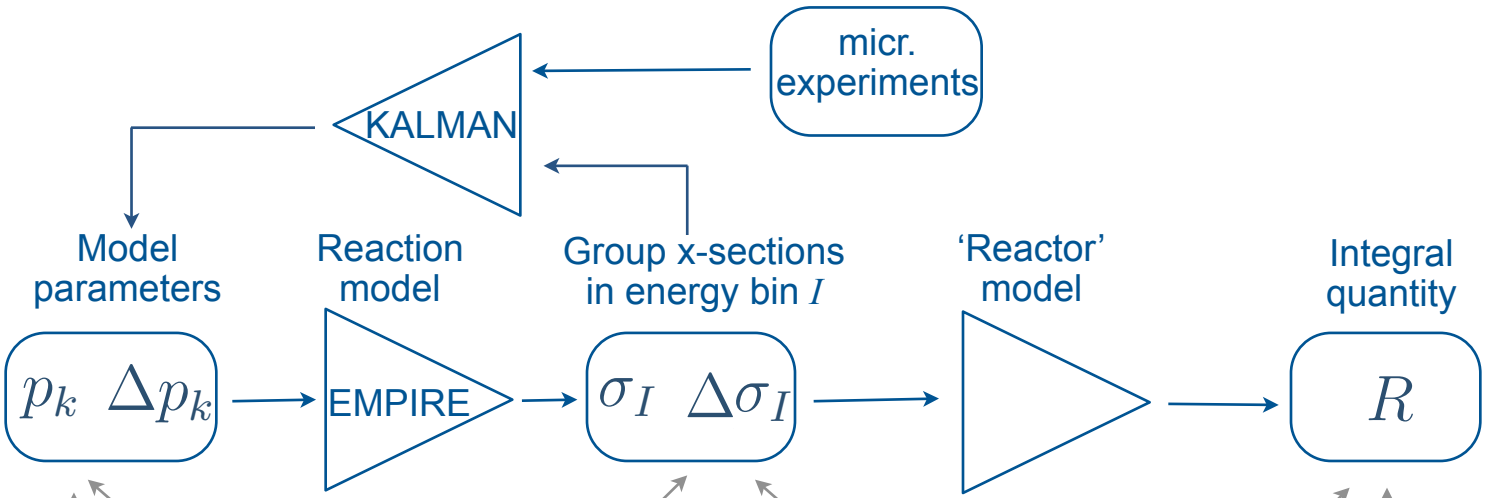
- JEFF-3.1 considered too low for ENDF/B-VII.0
- Very close to threshold discrepancy of 28% is observed!
- Only a few points modified to minimize changes



- Analogous procedure applied to the remaining two structural materials ^{52}Cr & ^{60}Ni

Assimilation (INL&BNL)

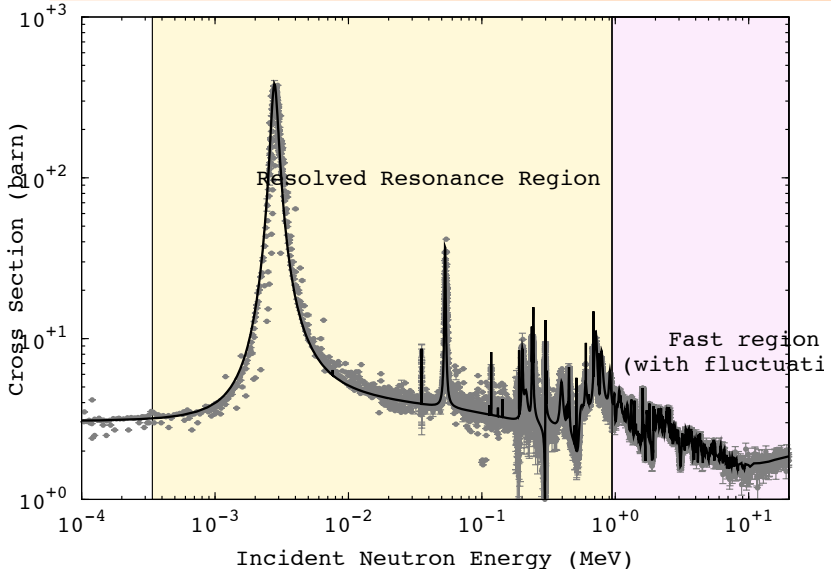
Linking integral experiments with reaction model parameters



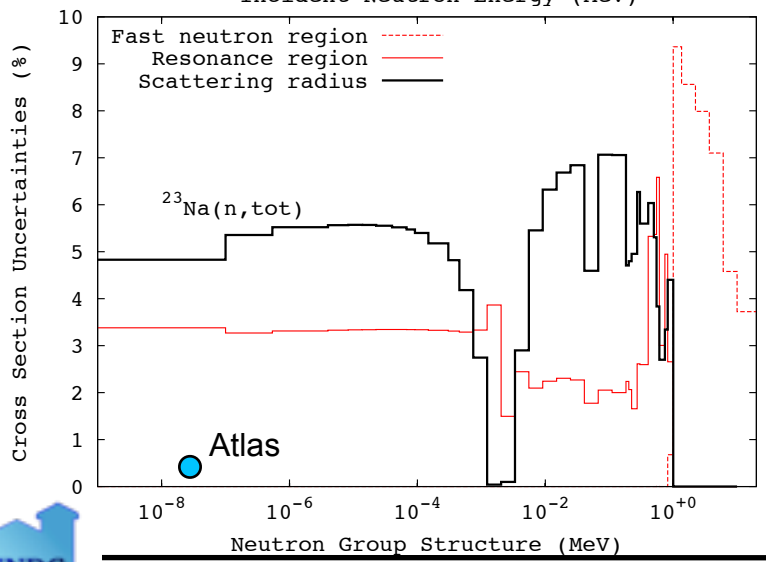
Using S_{Ik} , microscopic exp. data, and Kalman filter ==> $\langle \Delta p_k \, \Delta p_\ell \rangle$ covariance matrix, which contains constraints imposed by microscopic exp. data.

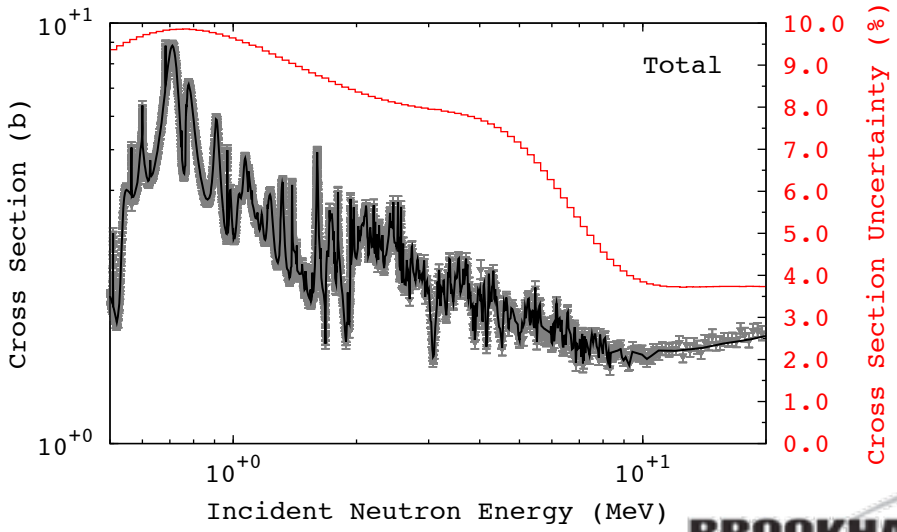
Assimilation

^{23}Na(n,*)



- EMPIRE/KALMAN used in the fast range
- Fluctuations in above 1 MeV reproduced with 'Tune' parameter in EMPIRE
- ~120 resonance and reaction model parameters varied
- Scattering radius included (no correlations)





Conclusions

- Covariances for 110 AFCI materials to be ENDF-6 formatted and included in the ENDF/B-VII.1 release in Dec. 2011
- Covariances for the priority materials included in the beta-0 version (Dec. 2010)
- BNL contributes to the processing codes comparison (see talk by Ramon)
- Quality Assurance - a smart system, influential system implemented at BNL (PO)
- We are still working on improving covariance methodology, e.g., 'kernel approach', assimilation, ...

Motto for covariances:

'Might not be perfect but must be sensible'